Application of the HVSR Microtremor Method for Basalt Outcrops in Tanjung Batu, Jambi

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Abstract. Microtremor data at 15 point had been taken at tanjung batu around of outcrop igneous rock in back arc basin south sumatra such as carried out at sub basin jambi. The igneous rock, which is found in this area, is basalt and distributed in ± 825 Ha and located in Desa Tanjung Batu Geragai Jambi. The uniqueness of this outcrop is it intrudes the thick of sedimentary rock which have the thickness around more than 1000 meter, located in east cost of Sumatera Island and far away from the volcanoes.
The natural frequency from 1-11 and 15 measurement point varied from 6 Hz-19 Hz. The amplification value from 1-10 and 15 measurement point varied from 0,8 Hz-2,2Hz, but at points 4 and 11 have amplification value from 3,4 Hz and 4,8 Hz. Seismic vulnerability at 1-10 and 15 measurement point varied from 0,8-1,8. but at points 4 and 11 have seismic vulnerability value from 1,4 and 2,3. From these result of natural frequency, amplification, and Seismic vulnerability in the outcrops have contrasting value in each map can be identified as fault from intrusion of basalt.

1. Introduction

Rock has his own natural frequency and will be different each other. The different of this natural frequency is depending on the physical properties of the rock such as density, velocity, and mineralogy of the rock. Natural frequency of the rock could be called as the natural signal from the subsurface and could be used to study and comprehend the condition geological structure beneath the surface. The way to study the natural frequency of the rock beneath the surface and to determine the subsurface geological structure is by applying the microtremor survey.
The existence of igneous rock in back arc basin such as carried out at Sub Basin Jambi could be said as the unique or a geological anomaly (Figure 2). The igneous rock, which is found in this area is basalt, distributed in ± 825 Ha and located in Desa Tanjung Batu Geragai Jambi. The uniqueness of this outcrop is it intrudes the thick of sedimentary rock which have the thickness around more than 1000 meter, located in east cost of Sumatera Island and far away from the volcanoes. Therefore, to comprehend the uniqueness of this anomaly, microtremor method was applied in this area. Natural frequency (f0), amplification (A0) and seismic vulnerability (Kg) were calculated in this research and interpret qualitatively.

2. Basic Theory of Microtremor and HVSR Analysis

The microtremor is a method in geophysics. Microtremor is categorized into a passive method, this method uses sources or direct responses from nature. Microtremor is a constant vibration on the earth's surface [1]. The source of microtremor vibrations comes from human or natural activities [2]. The intended vibration is not short duration [3]
Microtremor measurements were applied to see the conditions and characteristics of soil dynamics (natural frequency and amplification factors) which were viewed from seismic waves [4]. The microtremor is divided into two periods, a short period of 0.1 seconds to 1.6 seconds, and a long period of 1.6 seconds to 2 seconds.
Microtremor measurements produce data in a time domain with 3 components, 2 horizontal components and 1 vertical component. Data processing will use the HVSR method to produce natural frequencies and amplification factors. This value represents the characteristics and conditions of the soil or rock.

The HVSR method is used for processing data and will provide natural frequency values and amplification factors. HVSR method assumes horizontal and vertical spectrum comparison ratios are displacement functions [5].
This method is effective and economical to be used for dynamic characteristics of soil layers due to local geological effects [6]. Estimating the frequency value and amplification of geological conditions by comparing horizontal and vertical spectra [2].

- $HVSR = T_{site} = \frac{S_{HS}}{S_{vs}} = \frac{\sqrt{(north-south)^2 + (west-east)^2}}{V}$

S_{HS} horizontal component; S_{vs} vertical component.
HVSR is used to identify sediment responses. Response occurs due to seismic waves in the sediment due to contrast impedance between layers.

2.1 Natural Frequency
HVSR will produce natural frequency values and amplification factor values. natural frequencies represent the conditions and characteristics in the region. thick sedimentary layers will give a small frequency value [7]. low value natural frequency due to thick surface sediment, while high values natural frequency due to thin sediment [8].

Table 1. Classification of soil based on natural frequency value [9].

Soil Classification		Natural Frequency	Kanai Calssification	Soil Description
Class	Type			
I II	I	<2,5	Alluvial rocks formed from delta sedimentation, top soil, mud and other. With more than 30 meters deep.	Very thickness of surface sediments
III	I	2,5 - 4,0	Alluvial rocks with > 5 meter thickness. Consists of sandy-gravel, sandy hard clay, loam, etc.	Surface sediment thickness around 10 - 30 meters.
IV	I	4,0 - 10	alluvial rocks with 5 meters thickness. Consists of sandy-gravel, sandy hard clay, loam, etc.	Surface sediment thickness around 5 - 10 meters.
	II	6,667 - 20	tertiary of rocks. Consists of hard sandy, gravel, etc.	Sediment thickness is very thin and dominated by hard rocks.

2.2 Amplification Factor.
Amplification factors are derived from horizontal and vertical components on the surface in contact with the base layer [2]. Amplification is a wave increase due to material differences between layers.

amplification values in estimates of impedance contrast (density and velocity) of bedrock and surface sediment. high contrast impedance, then the high amplification factor value [10]. This value is caused by geological formation, layer thickness and physical properties [11]. The amplification value will be high if the rock has deformation.

Table 2. Amplification classification [11].

Zone	Classification	Amplification factor
1	Low	< 3
2	Normal	3 < A < 6
3	High	6 < A < 9
4	Very High	A > 9

2.3 Seismic Vulnerability

Seismic vulnerability is the level of vulnerability of surface rocks to deformation during an earthquake [12]. Geological condition factors are considered for determining the value of seismic vulnerabilities. Seismic vulnerability could be expressed as follow.

- $Kg = \frac{A0^2}{f0}$

Where A0 is amplification and f0 is the natural frequency.

3. Methodology

Measurements were carried out on basalt outcrops in Tanjung Batu village, Tanjung Jabung Timur, Jambi with 15 measurement data. Data is processed using the HVSR method with a Geopsy.

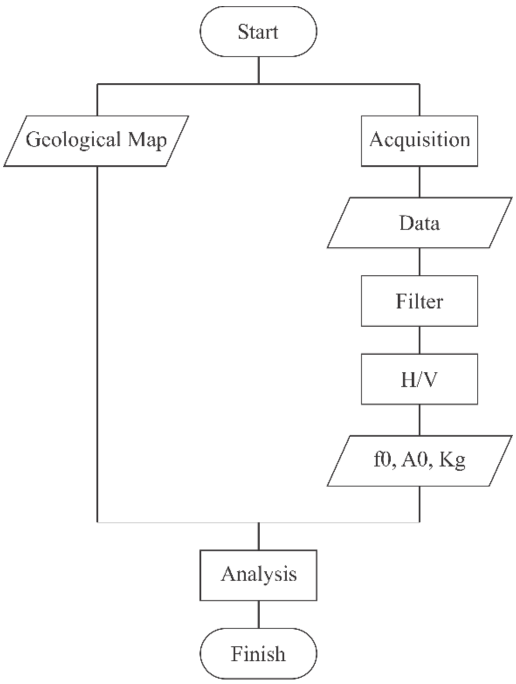

Figure 1. Flowchart.

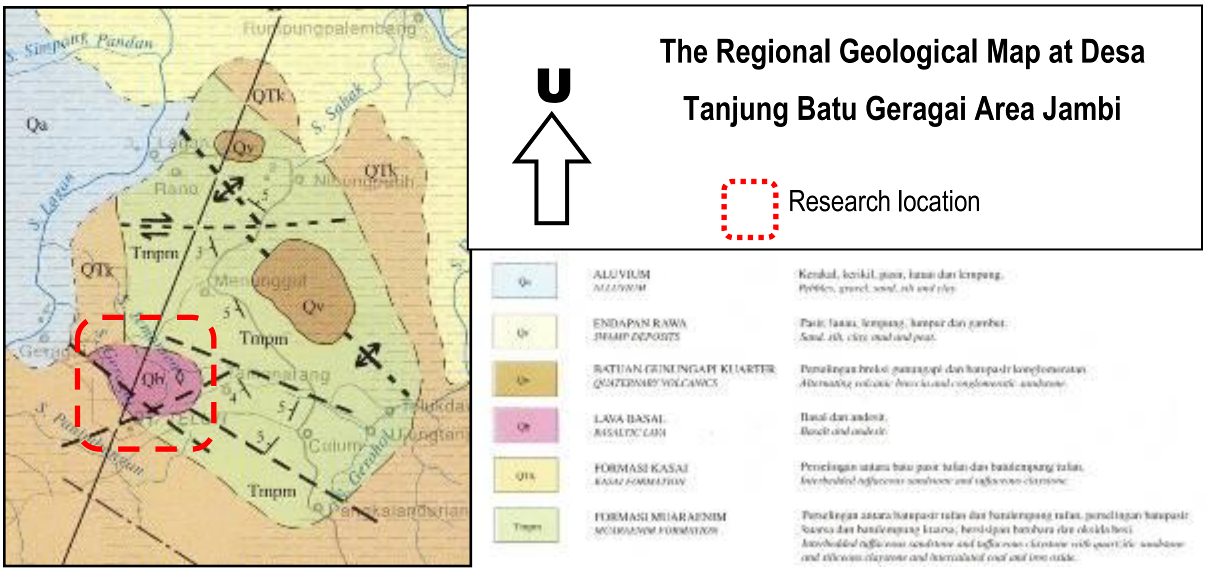

Figure 2. Distribution of lithology at research location.

3.1 Data Acquisition
The equipment used in this activity:

- Microtremor equipment MAE A6000S
- GPS
- Laptop
- Geological Map

The recording time at acquisition is 30 minutes.

3.2 Data Processing
Field data from the microtremor form is a file *.Sg2 and is processed using the HVSR method with Geopsy for natural frequency value, amplification value to calculate seismic vulnerability.

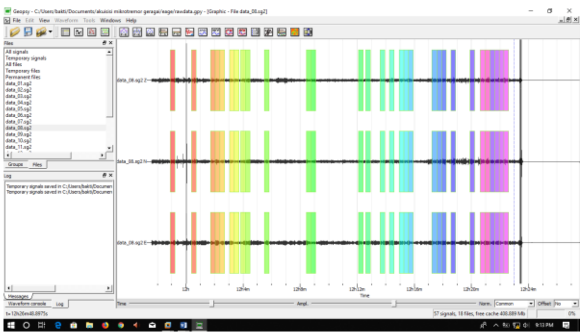

Figure 3. Time window selection

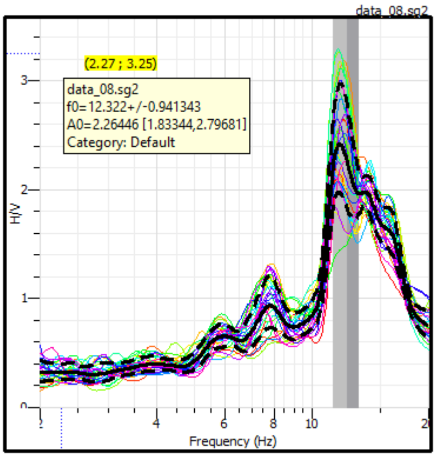

Figure 4. H/V Curve

4. Result and Data Analysis

Based on data processing at each point, the obtained natural frequency, amplification and seismic vulnerability. Then an analysis is performed by looking at the relationship between natural frequency, amplification, seismic vulnerability and the geological conditions on Tanjung Batu.

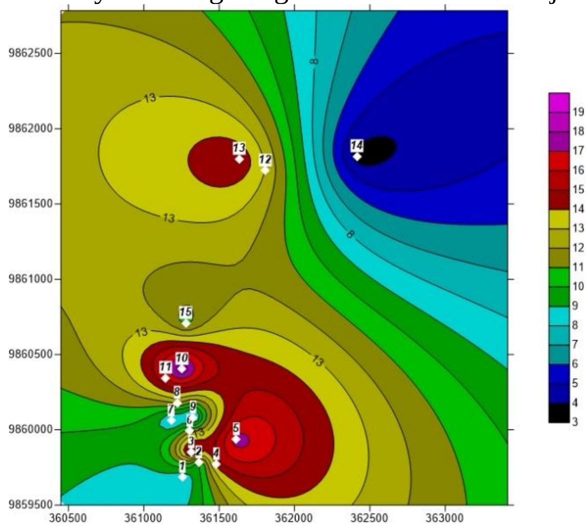

Figure 5. The Distribution of Natural Frequency

Figure 5 shows the distribution of natural frequency in the area Tanjung Batu. The results of natural frequency values have varying values from 3.56 Hz to 19.06 Hz. Measurements 1 through 11 and 15 are basalt outcrops. This region has a high natural frequency value from 6.84 Hz to 19.0 Hz. Referring to the soil classification table, measurements in this region are classified in type IV with a thin sediment layer of less than 5 meters and dominated by basaltic rocks. Measurements 12, 13 and 14 are in the north and have a natural frequency value of 12.98 Hz; 14.82 Hz; and 3.56 Hz. measurements 12 and 13 are classified as type IV. While measurement 14 is classified in type III with sediment thickness estimated at 10 to 30 meters

Figure 6 is an amplification distribution map. The H / V curve will give the amplification factor value. Amplification values are affected by wave velocity in layers and density. amplification factor values ranged from 0.69 Hz to 6.1 Hz. The measurement point could potentially experience amplification in measurement 4 with 4.67 Hz and measurement 11 with 6.1 Hz. measurements 4 and 11 have moderate risks based on the amplification classification table. Influenced by surface sediment materials and harder basaltic constituent materials. If there is movement, the surface sediment layer is easy to deformation. The other measurement points have a low risk because the amplification value is below 3 Hz.

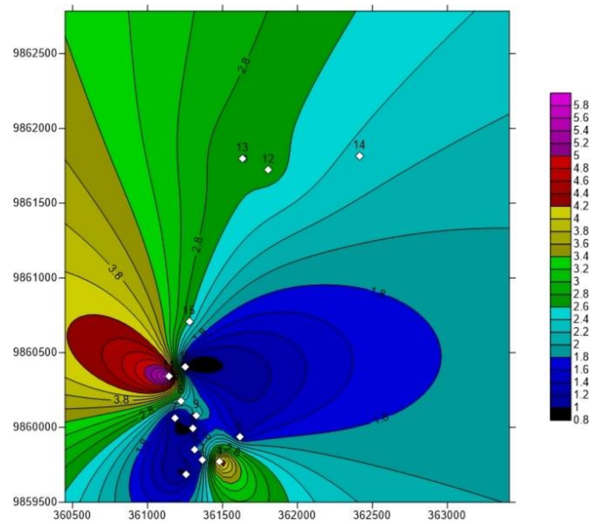

Figure 6. Amplification Distribution Map

Figure 7 shows the distribution of seismic vulnerability. Seismic vulnerability is the ability of rocks to deform due to ground or earthquake movements, this value will determine the zone of potential deformation. This value results from the ratio of the amplification factor and the natural frequency. The high value of the area's seismic vulnerability will potentially be a weak zone.

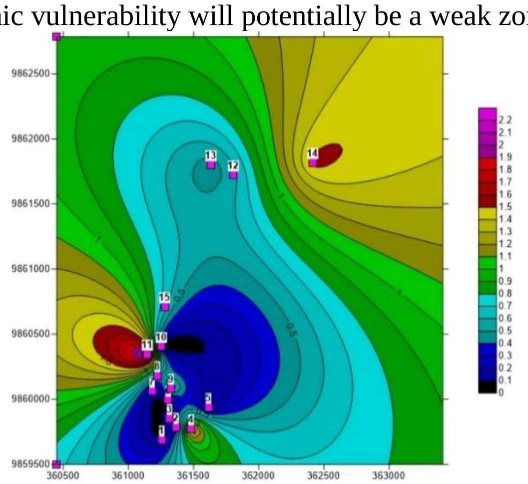

Figure 7. Distribution of Seismic Vulnerability

Seismic vulnerability values are between 0.02 to 2.32. The measurement point indicated to be a weak zone is the measurement point 4, 11 and 14. Seismic vulnerability at the measurement point 4 is 1.49; the measurement point 11 is 2.32; the measurement point 14 is 1.53. The measurement point has the potential to be a weak zone because there is a layer of sediment on the surface. If an earthquake or ground movement occurs, this zone is indicated to experience a movement. The intersection of the results shown on the microzonation map (Natural frequency, amplification and seismic vulnerability), is thought to be the result of a fault occurring during basalt rock intrusion. Basalt rock intrusion the region experienced deformation it would affect the natural frequency value, amplification factor and seismic vulnerability.

5. Conclusion

The natural frequency values in the basalt outcrops range from 3.56 Hz to 19.06 Hz. The amplification factor values in the basalt rock outcrops ranged from 0.69 Hz to 6.1 Hz. Seismic vulnerability values in basalt outcrops ranged from 0.02 to 2.32. Area in the basalt outcrop is still categorized in an area that is safe from ground and earthquake movements, does not rule out the possibility for some points to experience movement or deformation due to the earthquake**.** Deformed regions will affect natural frequencies, amplification factors and seismic vulnerabilities

6. Ackniwledgements

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7. References

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